THEORETICAL AND EXPERIMENTAL STUDIED OF THE THERMAL BEHAVIOR OF A LINEAR ELECTRO-MECHANICAL DEVICE

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ABSTRACT

The next generation of spacecraft structures are being made significantly smaller while still maintaining/increasing the tasks and functions of the particular missions. For missions planned to explore the distant portion of the solar system the operating temperatures are expected to be as low as 150K. This extremely low temperature introduces significant problems for solid-state electro-mechanical devices. Actuation devices, that can be considered for operation on such spacecraft, are required to provide high actuation accuracy, reliability, stability, light weight, small size, and to consume low power. The required functions of the devices include linear and rotation articulation and manipulation capabilities. JPL and UCLA are currently involved in developing such actuation device for the mosaicing mirror of the Pluto-Fast-Flyby (PFF) mission. The articulation of the PFF mosaic mirror requires a set of linear motors capable of operating at room and cryogenic temperatures. A commercially available motor is being examined analytically to determine its performance over the expected PFF operating temperature range.

The linear motor is modeled as a series of cylinders sequentially clamping and traveling over a shaft and its thermal electro-mechanical behavior is analyzed. The cylinders are assumed to be an elastic ensemble of active arid passive elements with the active materials poled in the radial direction and the material have temperature dependent properties. The closed form solution satisfies elasticity and Maxwell's equations and these parametric study demonstrate the feasibility of designing a thermally stable linear motor. Results suggest that present design limitations at low temperatures are attributed to mismatches in the materials' coefficient of thermal expansion (CTE) and a reduction in the piezoelectric response, The changes in these parameters, particularly the CTE, are the driving mechanisms rendering the motor inoperable at low temperatures. Our parametric study also seems to suggest that the motor low temperature limitations can be overcome by appropriate design modifications.

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